MANCHESTER 1824

The University of Manchester

Phased Array Feeds

Astronomical Instrument Development, DIAS

2nd September 2019

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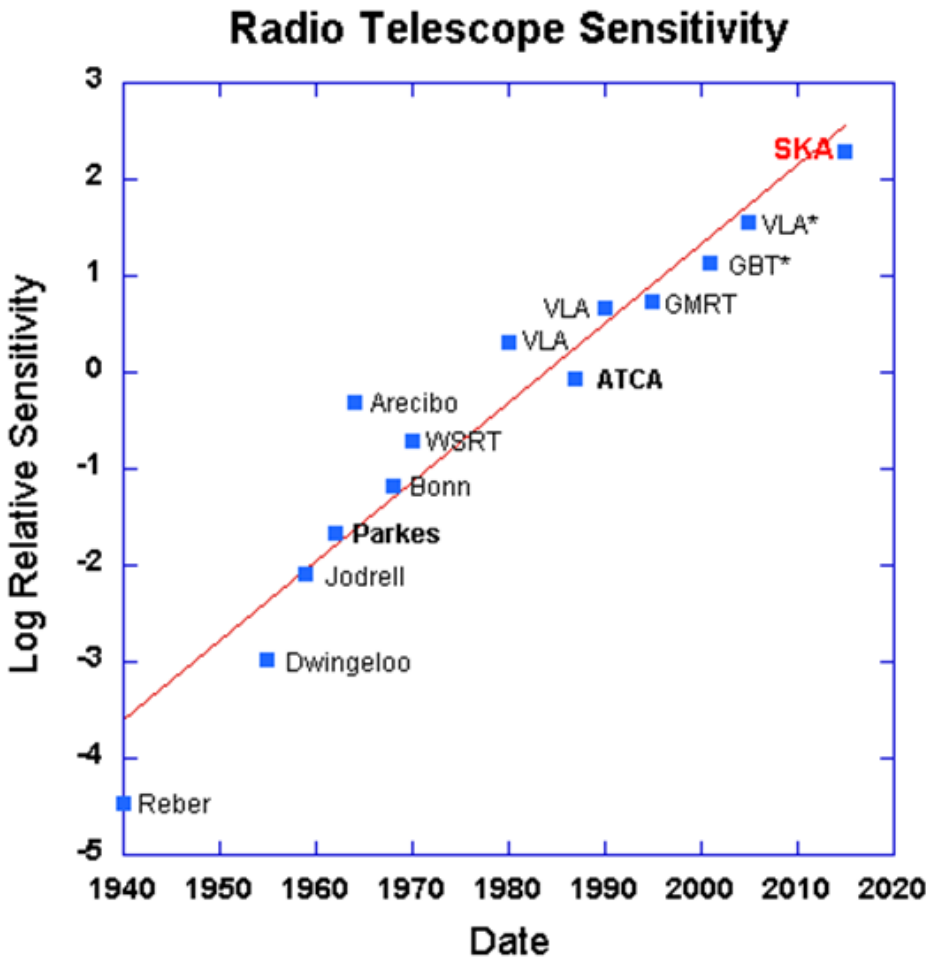
SKA and Signal and Data Transport

- SKA IGO Treaty signed March 2019
- Design Consortia have delivered CDR
- System CDR December 2019
- Construction to start Q1 2021
- UK led SDP and SADT Consortia
  - Strong involvement in NIP, TM, LFAA, DSH
- Signal and Data Transport Consortium
  - 14 institutes in 8 countries led by UoM
  - ~30,000 Gbit/s data transport
  - Frequency transfer (Allan deviation $< 10^{-12}$)
  - Clock, UTC transfer (1ns accuracy over 170 km; White Rabbit)
- Bridging work and prepare for construction contracts
- Observatory Development Programme…

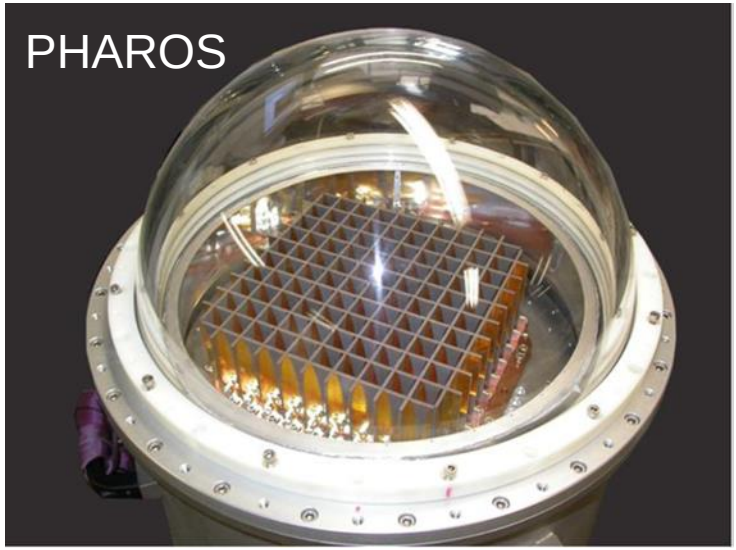
Progress in Radio Astronomy

- Exponential increase in capabilities over time
- SKA Band 2 receiver
  - T_{sys} = 16K
  - Full band digitised
- Where to next?
  - Cheap antennas?
    - Probably not
  - FoV…



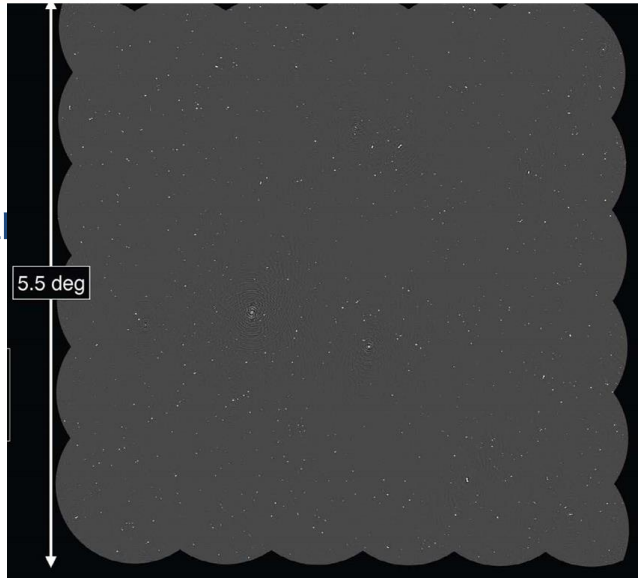
What is a PAF?

- Not the same as a Focal Plane Array (FPA)
- Phased Array Feed: Measure focal plane E-field with electrically small receptors.
- Apply complex weights and sum to form beams
- Repeat multiple times to dramatically increase field-of-view
- PAF systems now on telescopes
  - APERTIF
  - ASKAP

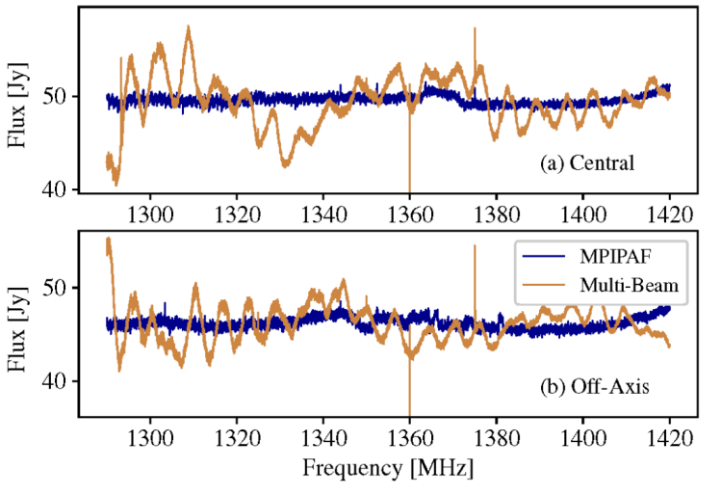


PAF Advantages

- Multiple simultaneous beams
  - E.g. 188 elements form 36 dual-poln bea
- Survey speed $\propto \left(\frac{A_e}{T_{sys}}\right)^2 \Omega$
- Increased self calibration potential
- Pointing errors
- Bandpass
- Tayloring the illumination function
  - Improve aperture efficiency
  - Reduce ground spill
  - Correct for dish imperfections
  - Deliberate under-illumination (?)
- RFI mitigation
  - Can not enforce too many nulls
- Polarisation purity
  - Large sensitivity cost



Credit: D McConnell; ASKAP image of NGC7232; 6x6 deg footprint



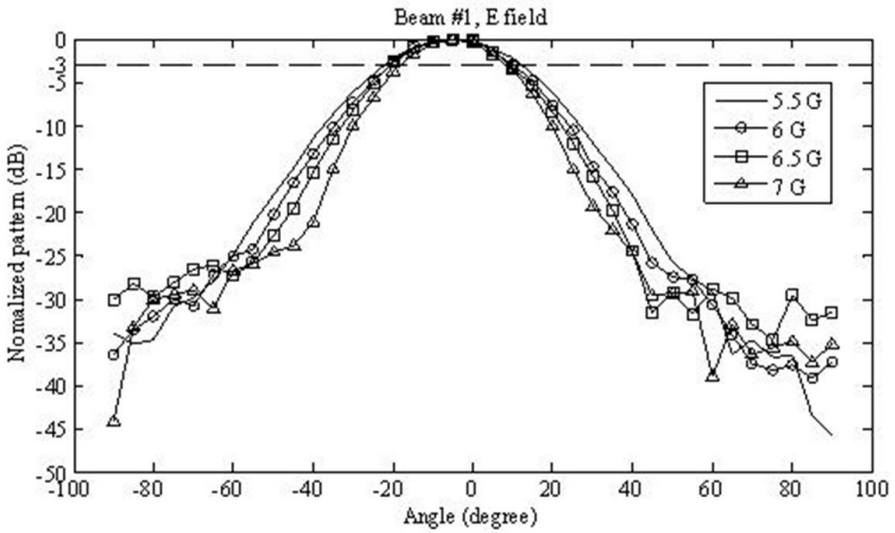
MPIPAF on Parkes

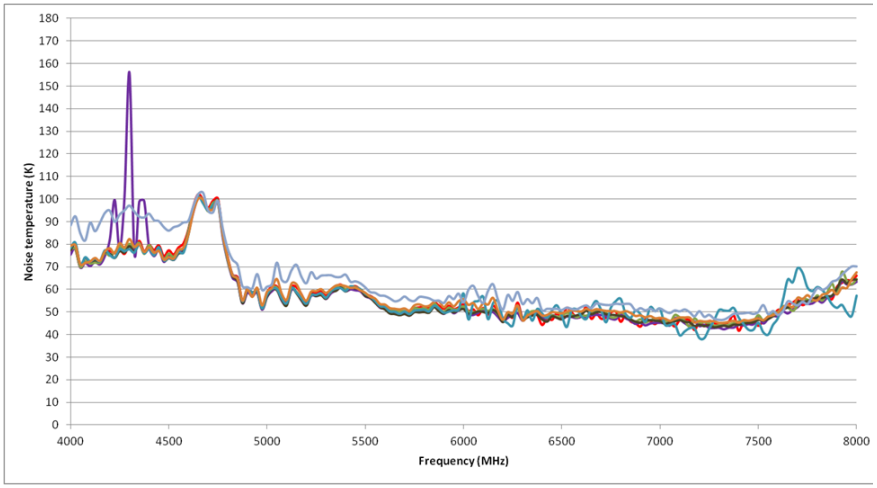
PAF cryogenic system

- Essential if desire same sensitivity as SPF
  - Rocket PAF may give Tsys = 35K
  - FLAG – 19 element Cryogenic L-band PAF mounted on GBT
  - T_receiver = 17K; matches GBT SPF
- “Expensive”
  - GM cooler takes ~ 5kW
  - LNF LNAs are €5k each; €700k to fill PAF (!)
- Just cool to ~ 70K?
  - Non-trivial
  - Effect of losses
- Investigate low cost LNAs
- Reduce cooling requirement; reduce mass
- Full system costs are important

Credit: Jeffs et al.

PHAROS and PHAROS2





- PHAROS – a C-band cryogenic PAF demonstrator (results above)
- PHAROS2: Prepare for full instrument
  - Improve sensitivity
  - Address scaling issues
- Low noise amplifiers
- Vacuum window
- Receiver elements
- IR filter
- Digital back-end
- Mount on telescope October 2019